

# Information Technology Fluency in Practice

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## ABSTRACT

Recent work has stressed the importance of fluency with information technology (IT) in the modern world. This report presents a set of context profiles that detail courses and programs to realize increased IT fluency across a small sampling of academic institutions. The goal is to provide some representative examples for other schools interested in addressing the issues associated with IT fluency.

## Categories and Subject Descriptors

K.3.2, K.3.m [Computing Milieux]: Computer and Information Science Education – *Literacy, Computer Literacy*

## General Terms

Design, Human Factors.

## Keywords

education, non-majors, IT fluency, FITness, context profiles, intellectual capabilities, computer applications, IT concepts

## INTRODUCTION

There has been substantial discussion regarding the preparation of the global workforce in terms of information technology (IT). While IT holds the promise of increased productivity, this promise is not realized due to the limited abilities of professionals to make use of IT. The rapid rate of change of IT mandates that people must be able to incorporate this technology continuously throughout their careers. Furthermore, the expansion of the “digital divide” threatens to create a permanent technical underclass, unable to effectively participate in their communities. The ability to make use of IT is known as fluency with IT (FIT),

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and is detailed in a subsequent section. The degree to which an individual can work with IT is sometimes called the level of FITness [6]. Fluency expands the domain of IT skills to include IT concepts and capabilities that scale over time.

Information technology has the potential to impact various aspects of society significantly. It facilitates a more accessible world, resulting in increased freedom of expression, increased access to information, and a reduction in remoteness [6]. Information technology can also impact equity in terms of gender, culture, and access for the disabled.

Since IT is anticipated to continually change, professionals need to be prepared for lifelong learning, a general goal of undergraduate education. Therefore, undergraduate computing programs have been encouraged to address this issue [1]. However, specific recommendations have been difficult to form due to the diversity of computing programs in terms of goals, faculty, IT resources, and student profiles.

The goal of this report is to complement [6] in terms of motivation and [1] in terms of policy, and thus provide examples of efforts to increase IT fluency in practice. It is hoped that these three reports work together so that academic institutions and programs wishing to increase the fluency of their students have the materials to support their objectives. In addition, this report is designed to serve as a stand-alone document for those outside the discipline of computing.

This working group report takes the bold step of tackling the issues involved in providing IT fluency. A set of context profiles that review recent efforts to address IT fluency is provided. Each context profile outlines the goals, means, resources and results for a given academic institution, program and student demographic. The degree to which the goals of IT fluency have been achieved is also given for these studies. This set is not exhaustive; rather, it consists of examples of various academic contexts that have minimal overlap. This set was also determined by the experience of the members of the working group.

## RELEVANT BACKGROUND

There exist efforts to give students the IT skills needed to utilize specific applications to solve problems of a particular type. For example, business schools teach spreadsheet applications that are essential for accounting, and a well-developed skill set contributes to the success of an accountant. This type of preparation that emphasizes skills alone is referred to as IT *literacy*, and suffers from the limitation of “perishability.” Continuous retraining becomes a prohibitive cost for organizations due to the increasing presence of IT in all aspects of modern society, as well as the rapid pace of the field. Still, many people feel underprepared to benefit from IT — sometimes to the point where they feel disadvantaged relative to their more “IT savvy” peers.

### Fluency with Information Technology

Recent work has motivated the move away from IT literacy and towards IT *fluency*, a broader concept describing effectiveness with IT. IT fluency components are specified as follows:

- ❑ *Contemporary skills* are needed for job readiness, and provide practical experience on which to build new competence.
- ❑ *Foundation concepts* are the “raw material” for understanding IT as it evolves, giving insight into the potential and limits of IT.
- ❑ *Intellectual capabilities* encourage abstract reasoning about IT to empower a person to exploit IT when possible and recover from the problems using IT.

These three components (each considered to be a type of knowledge) are complementary, and all are necessary. Ten items that are important for achieving each type of knowledge are specified in the National Research Council (NRC) report [6] and listed in the appendix. These items will be used throughout this report, as they are a reasonable basis for defining each type of knowledge. The NRC report remarks that FITness is personal (*i.e.*, there is no universal benchmark for defining a single measurement for FITness), graduated (*i.e.*, there are different levels of FITness, rather than just stating that an individual is or is not FIT), and dynamic, implying the need for lifelong learning as technology changes. Further details about the motivation for this balance are given in [6].

Closely related concepts of knowledge skills and abilities (KSAs) [21, 28], thought appropriate to graduates from programs which equip them for working in the IT field, have been independently discussed in prior work by [5, 18, 20].

### Computing Curricula 2001

The NRC report was used as a starting point to develop guidelines for “Computing Across the Curriculum” in Computing Curricula 2001 [1]. The pedagogy focus group responsible realized that outlining a complete set of procedures was impractical due to the diversity of colleges and universities, as well as the academic programs involved. The group chose to instead provide more general guidelines about the goals and intended outcomes from any curricular effort to increase student IT fluency. The guidelines took the form of interrogatories to assist in identifying significant issues in a specific context when implementing a curricular change for IT fluency.

The part of the report discussing computing for the general student population provides suggestions based on actual courses

that were considered successful as computing experiences for students outside of the computing majors. There were three distinct academic models proposed: i.) a general course for non-technical students; ii.) an interdisciplinary effort among a set of academic departments that includes computing; and iii.) a computing course for a specific student demographic (*e.g.*, bioinformatics for biology students).

There also exist other academic efforts to promote IT fluency that are not reported in the current paper. Some of these efforts include the “Fluency with IT” course conducted at the University of Washington [24]; a course that builds upon an initial survey course in computing for nonmajors using an interdisciplinary, case study approach at Temple University [2]; and computational approaches to science that afford an opportunity for science students to work with computers and programming, resulting in an increase in IT fluency as a positive side effect [23]. Other novel approaches exist to improve IT fluency [4, 10, 13, 14, 19, 22, 25, 26].

There are too many academic course sequences to discuss exhaustively because IT is pervasive in virtually all discipline contexts. Therefore, this report will present a set of samples that are designed to work with other reports to help various types of institution as they design curricula.

A set of context profiles is presented, each describing an academic experience to promote IT fluency. This set covers the following fields at different institutions: nursing, engineering, business (both general and IT orientations), liberal arts (both via CS0 and via CS1), informatics and econometrics. Other contexts that are not covered in this report but are appropriate for consideration include (but are not limited to): education (novice through professional), graphic design, architecture, life sciences, physical sciences, and law.

## CONTEXT PROFILES

Based upon the hypothesis that IT fluency is not simply a generic concept but actually varies across academic situations, the working group developed the concept of a “context profile” to depict how IT fluency is addressed in specific environments. It is hoped that these profiles may serve not only to illustrate actual examples of IT fluency practices in these selected circumstances, but also provide a comparative framework which may be used by others to transfer best IT fluency practices to their own institution. Transferring teaching practices from one situation to another is often problematic, but these context profiles borrow in part the concept of a practice “bundle” from the work of [11, 12] to aid in this process.

Each context profile consists of the following structure. An initial overview of the context is given, which includes institution, department and other relevant information. Next, student demographic information is presented in the form of exit and entrance profiles. Relevant information regarding the course goal (in terms of IT fluency), scheduling and resources is then outlined. Finally, the curricular experience is evaluated by describing what works (and what does not work) for the specific context.

### Business at AUT

This first context profile addresses the development of IT Fluency within a New Zealand Business Degree programme. The programme serves a wide range of business majors, and begins with a series of integrated interdisciplinary courses, so the

challenge in this case is to provide a generic solution within the integrated studies context.

### **Institution and Context Overview**

Auckland University of Technology (AUT) is situated in a metropolitan campus in downtown Auckland, with some 12,500 effective full time students and some 25,000 actual attendees, representing a large number of part time students studying while in employment. AUT is New Zealand's newest University – redesignated in 2000. Formerly a Polytechnic, AUT is over 100 years old as an institution, with a traditional emphasis upon applied learning and preparation of students for technical and professional occupations. It operates within the New Zealand educational environment based upon the British tradition, which unlike that of the North American breaks into a duration of five years at high school and three years for a typical undergraduate degree.

The professional computing disciplines are mostly housed within the School of Information Technology, within the Faculty of Business. Computing courses include much of the CS, SE and IS disciplines. Exceptions are CE, which is taught by the Science and Engineering Faculty, and end-user computing which is taught by the Computing Business Applications group. The range of programmes taught by the School of IT is diverse both in scope and multiplicity of levels. Courses range from pre-degree certificates and diplomas through to postgraduate masters and PHD programmes. The programmes tend to be aimed towards developing IT professionals, IT technicians or business professionals and, more recently, academic researchers as graduates. Thus, IT fluency is developed in different ways in each of the programmes. In some cases as an introductory skill set for intending IT professionals and in other cases as a broad set of underpinning capabilities for business professionals.

### **Student Exit Profile/Goal**

- Business undergraduate from integrated studies year, ready for further professional studies in a variety of business majors, including accounting, marketing, management, e-business, Information Technology, commercial law etc.

IT fluency is developed through two primary mechanisms in the Bachelor of Business Degree. This degree incorporates

- an introductory year of four integrated studies courses (2x30 credit papers constitute a full semester of study),
- a year and a half of professional papers in a chosen major or majors, and
- a semester of cooperative education off-campus in a business situation.

For general business students who do not elect an IT major, their IT fluency is developed only incidentally if their professional courses demand it, but initial exposure comes through the integrated studies courses. The philosophy here is to expose students to business in a wider context through an introductory series of integrated thematically linked courses. These integrated courses are titled:

- Environment of Business
- Business Information Management
- Globalisation and Business Enterprise
- Managing Business relationships

There are nine contending disciplines in these courses, including generic skills and capabilities, and such classic business disciplines as accounting, law, marketing, and management. These disciplines all contend for “air space” and are allocated an equal amount of time (approx 15 credits, or one course equivalent each over the foundation year). IT is just one of the courses, and has a total of 39 class contact hours across the four courses. In this limited time, some general information systems, networking and e-business concepts are covered and some personal productivity skills are developed, but the full range suggested to constitute IT fluency is not addressed in depth.

### **Student Entry Profile**

- Full time
- Part time – mature professional in employment, other
- Relatively balanced gender mix across business degree
- Culturally & ethnically diverse student body, large number of non-native language speakers (est. 30%) Ethnicities include NZ European, Maori, South East Asian, Pacific, Middle Eastern, Indian
- Some international full-fee paying students (est. 10%)

### **IT Fluency Components**

In the Integrated Business Studies context, IT fluency is developed through the cumulative combination of the integrated courses. Intellectual Capabilities are addressed through the combination of the topics addressed in the four integrated papers and by actively emphasizing general capability development. These include such capabilities as time management/forming teams; report writing; presentations; research - analysing and evaluating information. Information Technology Concepts are addressed to some extent through the combination of the topics addressed in the four integrated papers. The primary emphasis of the IT related coursework is on the role of information systems in the business context, and thus many of the more technical infrastructure and algorithmic concepts are given limited or no coverage. Information Technology Skills again are addressed through the combined effect of the interdisciplinary topics addressed in the four integrated papers. Again the emphasis on applications, including some additional to the FITness set, such as a statistical and an accounting package, has reduced the degree to which technology infrastructure topics are covered.

### **IT Resources**

The IT support for the Integrated Business Studies courses is generally similar to that for the Business IT professional majors discussed in a subsequent profile, save that students are exposed to a much reduced set of hardware environments and software applications. The Microsoft office suite is covered, together with an accounting package, a statistical package, the AUT Business Online (BOL) online learning management system, use of email, the campus network and a web browser for internet-based research.

### **Scheduling**

This sequence of integrated courses uses a mixture of approaches suitable for each discipline, including lectures, interactive discussions, reading, group work and closed laboratories. There are four two-hour sessions per week for each integrated course, with occasional extra one-hour sessions scheduled throughout the semester, which has a 15 week duration, the last two of which are

examination weeks. The nature of each course involves working through a multidisciplinary theme as indicated by the course titles, (e.g., business information management). The several discipline components, including the IT fluency elements are threaded into the course around each of these unifying themes. Faculty experts in their discipline area teach each separate discipline component. The IT faculty teaching on the programme are usually not from the IT school, but are housed within a separate Integrated Business Studies group. But at times faculty from the school of IT do teach on the programme to help cover additional student demand. Assessments comprise a balanced mixture of essays, examinations, research reports, business reports, presentations, web site evaluations and portfolio compilation across the four courses.

### Comments/Comparison to “FITness” Goals

*It works better if...*

- ❑ Examples and problems are grounded in the business contexts addressed within each theme, and the IT goals are linked with the broader syllabus, the related disciplines and the approach of the overall programme.
- ❑ Intellectual Capabilities are specifically identified and interdisciplinary assessments are designed with these capabilities in mind.
- ❑ The focus on contexts of use is retained, and teaching/learning approaches such as project or problem-based learning require the IT fluency to be gained as an inherent part of completing the coursework (*i.e.*, IT fluency is “built-in not bolted-on”).
- ❑ The teaching team works together on strategies to develop IT fluency throughout the course sequence, and it is truly integrated rather than “ghettoized” into the more IT specific sections of each course. The entire interdisciplinary team needs to become more IT fluent and aware of the level of proficiency required both of themselves and of the students.
- ❑ The teaching group have an IT champion who plans and coordinates the provision of IT resources, and creates a linkage from the interdisciplinary teaching team to the computing discipline experts in the school of IT to ensure the currency and rigour of the overall IT programme within the course sequence.
- ❑ The computing or IT school assigns “business-literate” faculty to the team who are committed to the integrated programme and teaching IT in this context.

*It doesn't work if...*

- ❑ IT fluency concepts are taught in a highly abstract manner, or in isolation without taking into account the integrated philosophy of the course sequence and the need for tight integration into the overall teaching programme.
- ❑ IT capabilities are unable to be fully developed, because the case studies selected for the course sequences are micro businesses, which offer limited scope to naturally address infrastructure or complexity considerations. However one strategy to extend a small business context is to pose such scenarios as the business being bought out by a large franchise operation, which mandates that certain key business systems such as standard infrastructure or custom applications be adopted by its outlets.

- ❑ Computing faculty have other demands on their time inconsistent with the needs of this programme (*e.g.*, unavailable for regular meetings of the integrated team, or unable to meet tight assessment turnaround deadlines on IT components of larger assignments, due to other workload peaks).
- ❑ Information Technology Skills are taught solely from a standard text, or by working through self-teach exercises with a by-the-numbers approach, and no connection with the rest of the course material and assessment programme.
- ❑ Information Technology Skills are taught without any mandatory assessment requirements.

### Business Information Technology at AUT

In this context profile the development of IT Fluency within AUT’s Bachelor of Business programme, is extended to meet the needs of IT related majors. Rather than a generic solution for all business majors, the challenge here is to provide a solution which develops high degrees of IT Fluency as befits graduates whose careers while business oriented, may involve a considerable IT dimension, with IT serving the role of a business enabler.

### Institution and Context Overview

Please see the overview in the previous profile (3.1.1).

### Student Exit Profile/Goal

- ❑ Business graduate ready for a professional career in a variety of IT related business areas, or for postgraduate studies.
- ❑ Other degree career change graduate, ready for professional career in a variety of IT related business areas, or for postgraduate studies.
- ❑ IT fluency (for more IT related majors) is developed through a further set of mechanisms in the Bachelor of Business Degree.

Among the available majors the two more IT oriented are Information Technology and E-Business. The school teaches the IT courses (15 credit papers of which four make a full semester of study). The six compulsory courses in the IT major are: Information Engineering, Human Computer Interaction, Managing the IS Development Process, Intelligent Business Systems, Strategic Data Management Architectures, and Electronic Business IT Infrastructures. The latter is also a paper for the e-Business major, which has one further IT paper “Making the Web Work for Business.”

The IT major is designed as a companion to another business related major, to suit a hybrid graduate as a business IT professional and has a very flat prerequisite structure, in which knowledge is not necessarily assumed from any other paper. The teaching and learning style generally tends to combine some theoretical aspects and some “hands-on” prototyping activity to give exposure to selected tools and techniques. One of the problematic issues has always been the level of prior knowledge to assume from students, with each class comprising students with quite varied IT fluency.

### Student Entry Profile

- ❑ Full time

- ❑ Part time – mature professional in employment, career change professional with first degree in another discipline or equivalent work experience, other
- ❑ Relatively balanced gender mix across business degree, less so in IT courses (est. 40% female)
- ❑ Cultural, ethnic and international mix similar to that for business degree as a whole.

### IT Fluency Components

In the Business IT context of the Bachelor of Business Degree, IT fluency is developed through the combined effect of:

- ❑ the prior integrated studies courses discussed above,
- ❑ incidental reinforcements in non-IT discipline papers,
- ❑ the six IT specific professional papers,
- ❑ the work-place based learning context of the cooperative education semester

Intellectual Capabilities are addressed through the six professional papers (Information Engineering; Management of the IS Development Process; Electronic Business IT Infrastructures; Strategic Data Management Architectures, Human Computer Interaction and Intelligent Business Systems) and a deliberate programme-wide pedagogical emphasis on developing broader student capabilities, such as: “cope with ambiguity and complexity” or “work effectively as a member of a team.” Information Technology Concepts are addressed through the combination of the six professional papers and the range of conceptual materials addressed in the courses. Information Technology Skills again are addressed through the combination of general and specific studies, the six professional papers, the cooperative education experience and the wide range of products and applications addressed throughout the programme.

### IT Resources

Students have access to both closed and open laboratories provided by the University, to the AUT network (Novell LAN with WindowsNT desktop machines) and the campus intranet, together with on campus Internet access, and off campus access via the Internet to the University’s digital library services. While most courses are conducted in face-to-face mode, some incorporate an online learning component, which uses the AUT developed Business On Line (BOL) learning management system, also accessible off campus. A wide variety of software is used throughout the programme, including: the standard Microsoft office desktop suite, Visio as a drawing package, Oracle as a DBMS, MYOB as an accounting package, SPSS for statistical analysis, MS-Project for project management, Director, Soundforge, Premiere, Photoshop for multimedia activities, Lotus Notes Domino for collaborative work, Linux and the Apache web server for networking and web related activities. Technical support for the environment and students is provided by a combination of the University’s central IT service group, Local Technicians within the Business Faculty, and help desk services for students and faculty. Open access labs are open from 7:00 am until 10:00 pm.

### Scheduling

As discussed above, the programme is taught as a sequence of courses using a mixture of lectures and closed laboratories. Courses are conducted over a 15-week semester, with 13 teaching weeks and two exam weeks, comprising 39 class contact hours

per course. The IT major courses are taught entirely by faculty from the School of Information Technology. Cooperative education students are supervised by faculty from the IT school, often in a group supervision model in partnership with faculty from the other business disciplines. In occasional courses such as Human Computer Interaction teaching assistants are used to help with the specialized software and in supervising the dedicated multimedia lab. The teaching/assessment approach tends to involve two major items of assessment per course, sometimes a staged project or prototyping exercise with some reflective element, complemented by a final examination.

### Comments/Comparison to “FITness” Goals

*It works better if...*

- ❑ Examples and problems are grounded in specific and comprehensible business contexts, and the IT goals are linked with the goals and approach of the degree.
- ❑ Intellectual Capabilities are specifically identified and assessments are designed with them in mind.
- ❑ The focus on contexts of use is retained, and teaching/learning approaches such as project or problem-based learning require the IT fluency to be gained as an inherent part of completing the coursework (*i.e.*, IT fluency is “built-in, not bolted-on”).
- ❑ The nature of the business student culture is acknowledged. At the risk of stereotyping, they tend to be more outcome-driven in their studies and less curiosity-driven. Therefore, it is important that critical IT fluency activity is closely tied to the assessment programme.

*It doesn’t work if...*

- ❑ More abstract and less connected concepts are taught in isolation or from a strongly technical or pure computer science perspective. For instance, in this programme the Algorithmic Thinking and Programming and the Universality components have been given little coverage. In fact, programming was deliberately de-emphasised and practically removed from the syllabus in 1997 in a redesign of the IT major. One or two small programming exercises remain, programming-like functionality is achieved through macros and database queries in desktop spreadsheet and database products, and some SQL is used for database querying. The redesign of the major was occasioned by severe failure rates and unsuccessful course experiences with more programming-focused courses, which left both faculty and students thoroughly unsatisfied. The redesigned IT major now focuses much more strongly on the needs of the business IT professional than those of the computer scientist or software developer, and its popularity with the student body has risen at least ten fold (from about twelve, to more than 120 IT major students), to the point where it is one of the most popular majors in the business degree.
- ❑ Information Technology Skills are taught solely from a standard text, or by working through self-teach exercises with a by-the-numbers approach, and no continuing need to exercise the skills, which have been acquired. Developing skills by designing assessments that require certain product functions to be mastered tends to be a more successful strategy.

## Nursing at Rivier

This section describes an information technology course created for students enrolled in a baccalaureate program in nursing at Rivier College.

### Institution and Context Overview

Rivier College is a private, Catholic American college. The majority of the students major in a pre-professional program: education, nursing, or business. There are approximately 1200 FTE (full time equivalent) undergraduate students – 50 computer science majors. (In addition to the computer science major, there is also a computer information systems degree, offered within the business department.) Approximately 750 students attend school full time, and 1250 attend on a part time basis. Many students are older. There is a Master's program, enrolling approximately 750 students, 100 of whom are computer science students. The majority of these students is part-time, and is generally taught by adjunct faculty. The school is considered to be a teaching college, and derives the majority of its operating expenses from tuition.

There is an "Introduction to Computers and Applications" course offered by the mathematics and computer science department. It is an elective class - not fulfilling any general education requirement. The class is mainly a skills class in learning to use a word processor, spreadsheet, database, and presentation system, and an introduction to the Internet. The business department offers an introduction to computers and computing class to all business majors, primarily a skills-based course.

The program designed for nursing students was to be a single information technology semester-long course, with upper-level nursing classes adding technology components (as needed) to continue nurses' exposure to, and comfort with, technology. The rest of this section discusses the information technology course.

Computer science faculty designed the course, with significant input from nursing faculty. The existing computer applications class was used as a basis; however, it was significantly modified. A class limit of 20 was set. (This had been done because the size of the computer laboratory to be used. It was a particularly good decision as the amount of attention needed by the students was such that a larger number of students would have provided a significant strain on the instructor.) The word processing part of the course was dropped (as most students already had exposure to a word processor. For those who did not, the academic computing services staff provided short tutorials.) An introduction to some nursing specific applications was provided, examples and projects involving use of spreadsheets and databases were tailored to nursing examples, and a small programming component was added (that involved having the students learn Visual Basic to be able to process and present data from one of the nursing applications (or from the spreadsheet). Additionally, an extra hour was added to the course, to be able to provide the students with more closed laboratory time. A large team project was added, with a group presentation.

### Student Exit Profile/Goal

The course took on a problem-solving approach. Aims of the course included to reduce technology anxiety, to learn about what a computer can be used for, to increase confidence in being willing to utilize new technology, to work on a team, to give a technical presentation of group results, to understand computer

inputs, outputs, and processing, to search for and manipulate information, and to use technology to solve problems.

### Student Entry Profile

The typical student to enter the course is a first or second year female nursing student. The student has approximately an equal chance of being traditionally aged or older.

### IT Fluency Components

The most heavily stressed objectives from [6] were:

- Using basic operating system features (skills). While not a particular goal of the course, sufficient laboratory work ensured this would be met.
- Using a graphics package to create expressions of ideas (skills). Students had a section on a presentation package, and presented their group reports using it.
- Using the Internet to find information and resources (skills). Students did this in lab, and one of the projects focused on this.
- Using a computer to communicate with others (skills). While not a focus area of the course, students actively participated on the class listserv.
- Using a spreadsheet (skills). Students had a section on learning MS Excel.
- Using a database (skills). Students had a section on learning MS Access.
- Using instructional materials to learn how to use new applications (skills). One of the possible group projects involved learning a new nursing application, and solving a problem with it. The group who did this presentation met with a sufficient degree of success that plans were made to incorporate this team's project into the curriculum for the future.
- Computers (concepts). Learning about the process of computation and what a computer does was a focus area of the course.
- Information systems (concepts). The heavy focus on information and information processing helped students to realize this concept.
- Modeling and abstraction (concepts). It had been planned to help students with the process of modeling problems in such a way as can be expressed in a particular computer application/environment, using abstraction to hide detail.
- Algorithmic thinking and programming (concepts). This included a programming section in VB (2 of the weekly labs, and part of 1 project). The group projects stressed algorithmic thinking and problem solving.
- Societal impact of information technology (concepts). 3 lectures and a lab were devoted to ethical issues of computing to the nursing profession.
- Sustained reasoning (capabilities). This is best illustrated in the group project. While the project statement is provided the students, they need to determine the approach to solving the problem.

- ❑ Organize information structures and evaluate information (capabilities). In the labs on spreadsheets, databases, and in projects, this is a major focus area.
- ❑ Collaborate (capabilities). The group project helps to meet this.

### IT Resources

Laboratory sessions were run in a computer classroom. The room consisted of 20 networked PCs, and an instructor's machine that was connected to a projector. Out of class the students in the campus laboratories generally completed assignments, especially when they involved nursing-specific software, which was not always available to students on their personal computers. As many students did not own their own computers, they did all of their work on the campus computers. Some did their assignments on out-of-class assignments.

### Scheduling

The course was run as a semester-long (15 week) class. It contained four contact hours per week. It was run as 50% lecture/50% laboratory, with latter parts of the course being primarily laboratory-based. Assessment was a combination of weekly lab practicums (meant to be completed in class), two larger lab projects, the team project and presentation, and examinations. Overall, students were quite satisfied with the pilot course that they took. Nursing staff was quite satisfied with the technological maturity these students exhibited the following semester.

### Comments/Comparison to "FITness" Goals

*It works better if...*

- ❑ A teaching assistant is assigned to the course.
- ❑ There are open laboratory hours (staffed by that teaching assistant).
- ❑ The skills and abilities learned/developed by the students are formally reinforced in their following year's nursing classes.

*It doesn't work if...*

- ❑ There is not sufficient staff assigned. When the course was first created, the plan had been to turn the course over to the nursing department (with computer science faculty staying involved in helping to update the course, based on technology), and/or for additional staff to be hired to run the course. However, none of the nursing faculty had become sufficiently comfortable with the course to teach it (and neither department had sufficient staff to run the course for all nursing majors). The result was that adjunct computer science faculty took over the teaching of the class, and it reverted to primarily a skills-based course, with the dropping of the teaching of the nursing-specific applications and the programming.

### Informatics and Econometrics at CUE

The Cracow University of Economics (CUE) differs from the other institutions referred to in this report in being larger than most, and in representing a situation typical for an eastern bloc country (Poland) still in the process of transition from a centralized economic system towards a market-oriented economy. For a large university such as CUE, it is impossible to analyze all offered curricula separately. Therefore, only two main groups will be differentiated among the CUE students: students studying the

informatics and econometrics majors (in the current context profile) and students of any other majors (in the subsequent context profile).

### Institution and Context Overview

CUE was founded in 1925. The present day, state owned University of Economics began its life as a private school called the College of Commerce. Granted academic status in 1937, the college assumed the name of CUE. After the Second World War, the university resumed regular classes in March 1945, teaching more than 2000 students during the 1946/47 academic year. The number of students then grew slowly up to approximately 7000 students in 1980. The University has three faculties: the Faculty of Economics, the Faculty of Management, and the Faculty of Commodity Science. Each of these faculties enjoys full academic status, and each is empowered to grant M.Sc. degrees, as well as doctoral degrees. The faculties are subdivided into organizational units called "chairs." A number of new specialized units of instruction have also been developed, including the School of Entrepreneurship and Management, the School of Information Technology, and Małopolska School of Public Administration. In 1999, 18,810 individuals studied at the University of Economics including 6,540 full time students, 11,671 extramural students and 599 postgraduate students (with 99 doctoral students). Those figures locate CUE among the larger universities in Poland.

The total number of faculty members is approximately 700 academic teachers. For IT education, two units are responsible: the Computer Science Chair, which consists of two departments, and a special unit called the School of Information Technology. These units consist of 25 academic teachers who run CS and IT oriented courses throughout the university.

It is worth noting that the organization of the study process significantly differs from the universities listed in the other context profiles in this report. It lies somewhere between the totally elective US system and highly centralized (*i.e.*, French system) since beginning students are assigned to groups of students with an identical curriculum throughout at least four semesters. Students can choose individual elective courses from the fifth semester. However, electives constitute only a certain percent of the learning load for an individual, while the student group curriculum dictates the majority of the required learning. All students are expected to examine and evaluate the impact of IT of economic decision-making at the strategic and local levels.

The Informatics and Econometric curriculum was designed as to prepare IT professionals ready to implement existing solution and developing new ones responding for the market demand.

### Student Exit Profile/Goal

The Informatics and Econometrics Curriculum is recognized as the most challenging curriculum at the CUE. Graduates of this curriculum are expected additionally present competence and skills on:

- ❑ Setting up a contemporary computer, including networking.
- ❑ Be ready to work in interdisciplinary teams on any scale IT related projects.
- ❑ Be able to develop application software as well as install proprietary integrated systems.

- ❑ Be efficient and professional in electronic collaboration on a global scale.

### Student Entry Profile

Students come to the university at variety levels of IT fluency. Those who apply for Informatics and Econometric possess skills that students of the other curricula are supposed to possess after the first year of study. This is because outsiders to this curriculum quite often are either already better prepared students of non-IT curricula, or they already have completed some vocational IT school or coursework.

### IT Fluency Components

The first stage of developing IT fluency consists of three courses that students must complete in three semesters. From the very beginning (*i.e.*, Introduction to Computer Science), students are trained in solving the same problems using different IT platforms and different technologies (*e.g.*, software packages, programming languages, etc.), while at the same time asked to develop their readiness for acquiring new, upcoming technology achievements.

During the second stage (*i.e.*, elective courses), theoretically, they complete much of the same courses as any other student, but in practice their assignments are quite often about developing software tools using technology enhanced presentations. This enables the course environment to be up to date with new concepts and technologies.

### IT Resources

The CUE Computational Center is an interfaculty unit responsible for supervising computer equipment, teaching support software and maintenance of network equipment. Over 250 computers are located in the student labs. Novell NetWare 4.11 servers are used mainly for teaching purposes. Unix system servers are also available: Linux, Solaris, and HP - UX. Altogether, seven Novell servers and four Unix servers have been installed to support closed and open lab student activities. All labs have access to the Internet and intranet resources. On an instructor's request, the access to the Internet might be suspended for a particular lab if such access is considered inappropriate. Students can use networked peripherals, especially to printers including color laser printers.

### Scheduling

The following courses constitute the base for developing student IT fluency on Informatics and Econometrics curriculum. The list is sorted increasingly along the number of semester the course starts. All courses are one semester long.

- ❑ Introduction to Computer Science (60, 1 semester),
- ❑ Computer Hardware Components (30, 2 semester),
- ❑ Algorithms and Data Structures (60, 3 semester),
- ❑ Information Systems Design (60, 5 semester),
- ❑ Operating Systems (60, 5 semester),
- ❑ Programming Languages and Methodology (60, 5 semester),
- ❑ Artificial Intelligence Methods (60, 5 semester),
- ❑ Distributed Systems (30, 6 semester),
- ❑ Object Oriented Programming and Design (30, 6 semester),

- ❑ Management Information Systems (45, 6 semester),
- ❑ Data Bases Management Systems (60, 7 semester),
- ❑ Computer Simulation Techniques (45, 7 semester),
- ❑ Data Visualization Methods (45, 7 semester),
- ❑ IT Projects Management (45, 8 semester),
- ❑ Computer Systems Security Issues (30, 8 semester),
- ❑ Programming in Distributed Environment (60, 8 semester),
- ❑ Elective lectures (330 hours total, 15 hours each course, semesters in range 8-10).

### Comments/Comparison to "FITness" Goals

*It works better if...*

- ❑ Students are motivated to improve their level of fluency on their own.
- ❑ Ways are established that a student can demonstrate his competency with IT fluency.

*It doesn't work if...*

- ❑ Courses in students' opinion are "too theoretical" and do not offer "hands on" activities wherever students expect they should
- ❑ University computer (lab) networks do not offer all required by teaching process services or the quality of some services is considered to be not satisfactory or outdated.

### Non-Informatics/Econometrics at CUE

This section contains additional comments on some specific experiences in promoting IT fluency for students at Cracow University of Economics with curricula different from Informatics and Econometrics.

### Institution and Context Overview

Please refer to section 3.4.1 in the previous context profile.

### Student Exit Profile/Goal

In addition to the University goals described earlier in this report, the course designers added some objectives designed to make course results easier to gauge. The most important are:

- ❑ Students should not be afraid of using a computer every time it is appropriate.
- ❑ Students should be confident in their ability to communicate efficiently with IT professionals.
- ❑ Students should be prepared for participating effectively in interdisciplinary teams working on IT implementation.

### Student Entry Profile

To become a full time student, one must pass a very competitive entrance exam. Therefore, full time students are recognized as a "better quality" group than part time students. The majority of students in both groups are young people who just have graduated from high school. Most of the part time students work concurrent to enrollment.

### IT Fluency Components

Basic skills and technological knowledge acquired by a student will be converted into IT fluency in two basic ways:

- ❑ Using IT technology available in conjunction with methods to solve problems doing projects, assignments and homework for other courses.
- ❑ Taking 10-15 hours of IT related elective courses designed to expand student's skills and knowledge in specific areas of specialization. The list of such electives varies from one year to another to keep up with progress in the technology.

### IT Resources

Please refer to section 3.4.5 in the previous context profile.

### Scheduling

All curricula but Informatics have similar course schedules. Computer Science Chair offers an "Informatics Foundation" course to every student starting his carrier at the CUE. The course is two semesters long and starts in the first semester. A weekly load consists of a one-hour lecture and a two-hour closed lab. Lectures serve to acquire knowledge about philosophy and recent achievements of IT, while labs are devoted to developing skills with common system environments and software tools such as word processors, spreadsheets and database management systems. Exposure to the Internet as a communication medium and a repository of useful data is also provided.

### Comments/Comparison to "FITness" Goals

*It works better if...*

- ❑ Students with non-IT majors have the opportunity to work together with IT majors during elective IT related courses.
- ❑ Students can formulate their specific expectation on the beginning of course.
- ❑ Instructors responsible for elective IT courses are selected from across the entire institution, similar to the SWED project (*i.e.*, system supporting educational environment), as described in [17] as the Reach Learning Environment.

*It doesn't work if...*

- ❑ Computer labs are overcrowded in the "Informatics Foundation" course offered in the initial two semesters. Although the computer labs are quite spacious (thirty seats), students groups need more space than thirty individuals, especially during first semester; furthermore, thirty people is too large a group for a single instructor;
- ❑ Students attend for credit only.

### Business at RMC

This section discusses the BA (Business Administration) programme at the Royal Military College of Canada (RMC).

### Institution and Context Overview

RMC is a small university located in Kingston, Ontario Canada with a total full time undergraduate enrolment of about 1000 students, and about 100-150 full time graduate students. RMC has about 140 full time civilian faculty members, and about 45 military faculty members. There are many adjunct faculty as well, the majority of whom are civilians, with an affiliation to the large civilian university nearby. RMC has recently celebrated its 125 anniversary, but it has only been a degree granting institution for about the past 40 years.

At the undergraduate level RMC is a bilingual institution, in that as Canada is a bilingual country (English and French), all officer cadets should have the option of studying in their language of choice. This means that all undergraduate courses are offered in both official languages. At the graduate level, although efforts are made to offer some courses in French, the majority of courses are offered in English.

### Student Exit Profile/Goal

RMC is primarily an engineering institution with over 50% of the students enrolled in engineering courses. However, with nearly 40% of the non-engineering students enrolling in Business administration after first year this means that about 70% of all students at RMC are enrolled in what would be considered as professional faculties at most universities. Therefore these students need to have an understanding of how IT will be used in their professions, as well as in the profession of arms. Although arguments can be made about additional work overloading students at any university as a military college this problem is particularly acute at RMC. Officer Cadets must demonstrate proficiency in each of the four pillars of their military education. As well as passing an academic programme all cadets must demonstrate proficiency in their second language, must maintain a high standard of physical fitness and must meet the objectives of their military training programme in order to graduate from RMC with a degree and a commission as an officer in the Canadian Forces.

### Student Entry Profile

All full time undergraduate students are members of the Canadian Military, with the majority of the undergraduate students being officer cadets, similar to the situation in the US military academies (*i.e.*, West Point, the Naval Academy or USAFA in Colorado), and a smaller number being officers of non commissioned members who are being sent to university on a full time basis to complete their degrees. As well as our full time undergraduate and graduate programmes, we provide a significant distance education program to a more varied clientele of military members, civilian members of our Department of National Defence, and dependents. In all there are up to 3,000 students taking part time courses.

### IT Fluency Components

Students in Business Administration take two courses dedicated to Information Systems and Information Technology. They also take a number of other courses that require the students to use and understand specific programs and computer based analytical techniques. The goals of the introductory and follow-up course in IT/IS are to increase the level of IT skills and the familiarity of the students with information technology and information systems concepts. During the first course students will obtain some level of understanding of how to set up a personal computer and will have access to a computer lab for up to ten lecture periods. During these periods students learn how to use (or to improve their skills with) word processors, presentation packages, spreadsheets, email programmes, web browsers and other relevant packages for business students. Students should be familiar with the components of a computer system (hardware, software, peripherals) and have an idea of the history of computing. They need to understand some basic systems theory, and the usefulness of the different types of IS, such as MIS, DSS and EDSS. They also get an introduction to networking concepts and the digital representation of data, and data management in information

systems. Final sections of the course discuss the use of IT/IS in managerial decision making, strategic use of IS and ethical issues.

After the second course students will have a better understanding of IS, an introduction to the concepts of E-Commerce, the uses of IS in organizations, and systems design and development issues. By the end of both courses they will also have an understanding of the basic concepts involved in data management.

### IT Resources

All Officer Cadets at the college have access to general computer labs that have a standard configuration. In addition the students in Business Administration have access to a specific twenty-computer business-computing lab whose machines have additional applications packages in addition to the standard college software. The majority of computer labs at RMC use Windows based PC's, except the engineering graphics workstations, which use the Unix operating system. The general and the business computing labs may be closed for laboratory teaching, but are normally open 15 hours a weekday for students to use. RMC has Internet access in all officers, and the labs, and as well all students have access in their rooms.

There is also an Intranet on campus. There is a computing services help desk that operates 9-5 on weekdays, and in the department of Business Administration a technician is available if there are serious problems in the lab. Almost all students live on campus, but the graduate students and faculty have dial up access to RMC, or can access parts of the intranet from the Internet. Students working in the Business lab can print out on the lasers printers there, or can request access to a departmental color laser printer. All students in all labs, or on the intranet have access to computer services high-speed laser printers including color laser printers. However access to these college wide resources are often restricted outside of the standard workweek.

### Scheduling

At RMC the Department of Mathematics and Computer Science provides Computer Science courses to Science and Engineering Students, and to students in the Faculty of Arts who are not enrolled in Business Administration. Currently students in the Faculty of Arts outside of the Department of Business Administration take one half course (three hours per week of lectures, for a thirteen week term) in computer fundamentals, or an introduction to information technology from the Department of Mathematics and Computer Science.

The Department of Business Administration has recently redeveloped the Introduction to Information Technology (BAE/AAF 220A) course, which is now a second year, half-year course. It is an introduction to information technology and information systems course. Students in Business Administration take an additional course in Information Systems (BAE/AAF 410) in fourth year, and have instruction in the use of computers for business simulation in one of their quantitative methods courses, and use computers for gaming or simulation in other courses. Assessment in the BAE/AAF 220 course is based on a final essay style exam (50%) that test the students ability to make use of concepts, a course paper (10 pages) where the students describe how an organization uses IT/IS, and five smaller assignments that test students' understanding of the material and skills. Course descriptions can be found on the RMC website at the URL [www.rmc.ca](http://www.rmc.ca).

### Comments/Comparison to "FITNESS" Goals

Students in this programme also need to achieve a high level on most of the subcategories in the Information Technology category, with the exception of algorithmic thinking about programming and information organization (Please see the tables at the end of the report for details on how the programme meets each of the 30 individual requirements).

Students only require a medium or low level of proficiency on the majority of the Information Technology skills areas, although they are required to develop relatively high levels of proficiency in their ability to use an integrated officer package that should include a word processor, presentation graphics package and a spreadsheet. They also need a high level of proficiency in using the Internet to find information.

*It works better if...*

- ❑ The Intellectual Capabilities can be addressed by the entire programme, not by the IT courses themselves. This means that it is appropriate to think of technology as being one component of the environment, and that students who are being taught how to handle complexity, or deal with uncertainty, or project management skills in a general context, will meet the Intellectual Capabilities requirements for these issues.
- ❑ The students are engaged in using the technology. This means that having student groups prepare presentations during the term which involve demonstrating a number of the requisite skills with graphics packages, and ability to access the internet, as well as communications skills etc., keeps the students more interested and engaged. The course becomes less of a necessary evil, and more fun.

*It doesn't work if...*

- ❑ The IT course is taught by the Department of Math and Computer Science as a general course, and is not tailored to the needs and interests of the business administration students.
- ❑ The course focuses on programming or technical issues and not on the uses of the technology in organizational settings.

### Engineering at RMC

This section of the report discusses the Bachelor of Engineering (B.Eng) programs at RMC.

### Institution and Context Overview

Please refer to the overview in the previous profile (3.6.1).

### Student Exit Profile/Goal

We are also primarily an engineering institution with over 50% of our students enrolled in engineering courses. However, with nearly 40% of the non-engineering students enrolling in Business Administration after first year this means that about 70% of all students at RMC are enrolled in what would be considered as professional faculties at most universities. Therefore these students need to have an understanding of how IT will be used in their professions, as well as in the profession of arms. The engineering programs at RMC undergo periodic accreditation by the national accreditation board. Therefore RMC graduates are entitled to apply for registration as professional engineers with the various provincial regulatory bodies.

## Student Entry Profile

All full time undergraduate students are members of the Canadian Military, with the majority of the undergraduate students being officer cadets, similar to the situation in the US military academies (*i.e.*, West Point, the Naval Academy or USAFA in Colorado), and a smaller number being officers of non commissioned members who are being sent to university on a full time basis to complete their degrees. Academically nearly all of the engineering students placed in the top 10% of their graduating class in secondary school.

## IT Fluency Components

In comparing with the three major categories, it would seem that the majority of engineering students would score high on the Information Technology Skills and Concepts categories, with the exceptions of the Information Organization and Information Systems areas. However, some students, (*i.e.*, those in Computer Engineering or those who are taking CE options) would have high levels of achievement in these areas as well. The initial courses in computing and engineering graphics are designed to teach the students many of the IT technology concepts, with the exception of the limitations of IT and the societal impact of information technology. However, students take other courses in ethics and the impact of technology on society in general where these topics are covered.

## IT Resources

Please see section 3.6.5 in the previous profile.

## Scheduling

At RMC the Department of Mathematics and Computer Science provides Computer Science courses to Science and Engineering Students, and to students in the Faculty of Arts who are not enrolled in Business Administration. Currently students in the Faculty of take one half course (three hours per week of lectures, for a thirteen week term) in computer science fundamentals in their first year. All engineering students take a one half course in engineering graphics in second year which requires them to use the engineering graphics workstations. Students in mechanical and civil engineering take a second course in engineering graphics. All engineering students take courses in calculus and algebra from the Department of Mathematics and Computer Science, and may use programs such as TK Solver in these courses. They also are required to make use of computer technology in their other basic science courses (such as physics and chemistry). Course descriptions can be found on the RMC website at [www.rmc.ca](http://www.rmc.ca).

## Comments/Comparison to “FITness” Goals

Engineering students use computers in a number of their courses. Although only the computer engineering students’ work are focused on computer technology all engineers today must understand how to make use of IT in their professional lives. It is believed that at the end of their four years all engineering students have achieved a level of fluency in information technology concepts. Students should be familiar with the components of a computer system (hardware, software, peripherals) and have an idea of the history of computing. However few of the students will have an understanding of many of the organizational uses of IT and IM and of the ethical issues related to the use of IT. (Details are provided in the tables at the end of the report).

The entire programme covers many of the concepts found in the Intellectual Capabilities area, where students learn to use

technology. If we compare the engineering and business students, we see that the engineering students have a more general understanding of technology learned from a variety of their engineering courses, and how technology is used by society. They should have the ability to deduce from this knowledge base, and their understanding of computers how IT fits into our society.

*It works better if...*

- ❑ All Engineers today must understand how to make use of IT in their professional lives.
- ❑ An Engineering professor teaches the FITness courses offered to Engineering students. Engineering students tend to accord face validity to engineers, and it has been demonstrated with other courses that they tend to place a lower value on courses outside of their hard core of engineering subjects unless the instructor can bring validity to that course.

*It doesn’t work if...*

- ❑ A non-engineer teaches the introductory course from a purely theoretical viewpoint. Face validity is important when providing service courses for engineering students.
- ❑ The engineering professor assigned to teach the course does not work with the Mathematics and Computer Science department to stay current with developments in IS/IT and teaching FIT concepts.

## Liberal Arts, CS-0 Based at Haverford

This section outlines a specific experience promoting IT fluency for students at Haverford College, a small liberal arts college in the eastern United States. The primary vehicle is a non-majors computing survey course (CMSC100) that students can use to fulfill a quantitative requirement for graduation.

## Institution and Context Overview

Haverford College is a liberal arts school of approximately 1,000 undergraduates from the divisions of humanities, social sciences, and natural sciences. There are approximately 100 faculty members, with three in the Department of Computer Science. A single computer science faculty member is teaching IT fluency explicitly. Affiliated faculty from nearby Bryn Mawr and Swarthmore Colleges provide some breadth. Between three and five computer science majors graduate annually, divided between graduate study and industrial careers. There is a concentration in computer science available to majors in mathematics and physics, as well as a minor in computer science available to all students.

## Student Exit Profile/Goal

The course goals involve IT fluency as stated in [6], but only as an alternative objective. The primary goal is a tour of relevant computer science topics, including history, interfaces, the Internet, programming, translation, logic design, theory and artificial intelligence [7]. IT fluency is addressed through two vehicles: a case study in economics (described later) and a term project.

## Student Entry Profile

The target audience includes students from the humanities or the social sciences where it is likely to find people with minimal IT background, and sometimes even fear of IT.

## IT Fluency Components

The following capabilities, concepts and skills are explicit learning outcomes where a high level of fluency is sought:

### Capabilities:

- ❑ engage in sustained reasoning: Students need to be able to understand a problem, specify and design a solution, and complete the implementation over the course of a few days or weeks.
- ❑ organize and evaluate information structures and evaluate information: This capability is required during the IT case study when downloading raw data, as well as importing this data into the statistics application.

### Concepts:

- ❑ digital representation of information: Students work through examples to show that digital information can be used to represent text, sound, speech, and graphics.
- ❑ modeling and abstraction: Students are expected to be able to reason about a few IT abstractions, including the operating system and remote services.
- ❑ limitations of IT: There is an explicit discussion of unsolvability and intractability in the context of computer science. Additionally, issues of dependability are studied.
- ❑ societal impact of information and IT: These students are more likely to use an application than develop one in their future. Thus, an understanding of the relationship between society and IT is considered important.

### Skills:

- ❑ using basic operating system features: Each student should be able to reason abstractly about the operating system in its roles as interface and resource manager. Experience with one platform should help each student as they move to work on another platform.
- ❑ using a word processor: These students are asked to express their thoughts and reactions in many contexts. A word processor should be another tool to help in this expression.
- ❑ using the Internet to find resources: Students are required to use IT should facilitate discovery and acquisition of information from various sources, including the Internet.
- ❑ using an application to analyze data: This course acts to fulfill a quantitative graduation requirement. The analysis portion of the economics case study addresses this requirement, as well as this particular skill.

A moderate level of fluency is sought for the following attributes: the capabilities of collaborate, communicate to other audiences, expect the unexpected, and think about IT abstractly; the concept of universality; and the skills of setting up a PC, using a computer to communicate with others, using a spreadsheet to model simple processes, and using instructional materials to learn how to use new applications or features. The remaining items are of low priority. The table in the appendix lists the expected level for all thirty IT fluency components.

### IT Resources

The computer science department maintains a ten workstation dual boot Linux/Windows lab. Regular closed, instructor supervised lab times are maintained. However, all lab work can be completed using student resources in the residence halls so that they are not bound to the lab.

The campus academic computing center (ACC) provides other open labs of Macintosh and Windows PCs, helpdesk access for students in cases of computer or software failure, and servers containing needed software applications. Students also have email access to the instructor (and each other), as well as materials maintained on a course website. Students can work from anywhere on campus via a campus Ethernet LAN. All software required is available as part of the student's computer (e.g., operating system), free (e.g., browser), or supplied with the course text (e.g., logic breadboard simulator). Occasionally, a dedicated teaching assistant has been utilized with positive results.

### Scheduling

The computing survey and IT fluency course is conducted with three lectures (one hour each) and one lab/discussion session (one hour) per week. Students are expected to complete a set of five lab assignments, as well as a term project. This project is selected from the following choices: i.) a paper on a subject related to computer science and IT; ii.) a more substantial programming assignment than the third lab; or iii.) a more substantial treatment similar to the economics case study. Each student prepares a project proposal by midterm, which is reviewed by the instructor.

IT fluency is injected into this context using guidelines proposed by the ITF framework [8, 16]. These guidelines assisted in the development of a case study in economics where students use non-trivial, domain-specific applications to find data and propose a resolution of the question, "Does money buy happiness?" An economics professor provides a guest lecture to demonstrate the process of finding relevant raw data, downloading and then processing this data to draw reasonable conclusions. The students are asked to use *Stata*, an application for statistical analysis. Raw economic data is obtained from the World Wide Web.

Students are initially presented with a lecture discussing IT fluency. Next, the economics professor visits the class and presents an example to locate, download, and statistically process appropriate raw data, to uncover evidence to address the question of money and happiness. Finally, students are asked to experiment for themselves. Most of this work occurs outside of class, either during scheduled lab/discussion times or during office visits with the course instructor.

Typically, the course is team-taught, but has been conducted by a single professor of computer science. Assessment involves three examinations, as well as grades for the five labs and single term project. Details for this course can be found on the web [www.cs.haverford.edu](http://www.cs.haverford.edu), or in [9].

### Comments/Comparison to "FITness" Goals

This section presents a brief discussion of the effectiveness, as well as the limits, of this approach.

#### *It works better if...*

- ❑ Students are given clear directions early in the course.
- ❑ Students are required to submit the project proposals at midterm. This requirement motivates them to think through the exercise, as well as provides a chance for early feedback either supporting or adjusting the proposal.
- ❑ Guided discussion group meeting outside of lecture. Again, students respond well when receiving constructive comments in a timely manner.

- ❑ Selecting projects and labs that are of interest to the student and are slightly beyond the immediate reach of the student induces much satisfaction when the project is completed.

*It doesn't work if...*

- ❑ The exercises are not properly structured and supported by the instructor. Small problems frustrate students easily.
- ❑ Problems arise if staffing does not scale with class enrollments.
- ❑ The IT fluency term project should be required because these students will almost always choose to compose a paper if provided such an option.

### **Liberal Arts, CS1-Based at Vassar**

This study describes the approach used to promote IT fluency at Vassar College. As is likely the case at many other small institutions, the Computer Science Department does not have the resources to offer an IT fluency course targeted only at non-majors. Instead, the first course (CMPU 101) has been designed to serve as a broad introduction to computing and technology for both majors and non-majors.

### **Institution and Context Overview**

Founded in 1861, Vassar College is a highly selective, residential, coeducational liberal arts college with approximately 2400 students and 220 full-time faculty members. Vassar was a women's college until 1969, and the majority of the student body (roughly 60%) still consists of women. The Computer Science Department has six full-time faculty and about 50 majors. The 12 to 15 computer science majors that graduate each year split almost evenly between industry careers and graduate study. Students are not required to take any courses in the Computer Science Department, though CMPU 101 satisfies a quantitative requirement and is taken by roughly 100 students each year. (Sections are limited to 20 students, and five sections per year are offered.)

As the department offers no courses targeted specifically to non-majors, CMPU 101 has been designed both to introduce computing to students intending to major in Computer Science, and to give a broad introduction to the field, including some IT fluency, to those who choose not to take additional computing classes. This has influenced the design of the course in a number of ways. First, it introduces programming via Scheme, thereby limiting the time required to learn syntax and programming environments, and allowing a high-level presentation of algorithms and data structures. Second, an effort is made to include historical background as well as the "great ideas" in computing. Finally, in an effort to provide additional IT fluency, students are assigned readings from [27] covering topics such as ethics, copyright law, computational complexity, and the limits of computing.

### **Student Exit Profile/Goal**

As a liberal arts institution, Vassar expects all graduating students to be broadly educated, to have excellent communication skills, and to be flexible and creative problem solvers. Currently, there are no requirements to ensure that graduating students are fluent with information technology, though some level of IT fluency is clearly required by all liberal arts graduates if they are to meet the goals above. (See the tables in the appendix for expected fluency levels.) Students majoring in the sciences are expected to have

additional fluency with IT in preparation for graduate study or careers in industry.

### **Student Entry Profile**

Incoming students are selected primarily on the basis of prior academic excellence. Roughly 60% of Vassar students come from the public school system, 40% from private. Between 22% and 25% of the student body identify themselves as students of color, with 5% of the total population being international students. Virtually all incoming students are familiar enough with information technology to use common productivity applications (e.g., word processor, spreadsheet, email), and many students taking computing courses have had previous programming experience at the high-school level.

Students enrolling in CMPU 101 have a wide variety of backgrounds and interests. Fewer than 15% typically continue on to major in Computer Science, with the remaining students split fairly evenly between majors in the arts and in the sciences. The latter breakdown is difficult to measure precisely, since many students take it during their first or second year and may not yet have declared a major.

### **IT Fluency Components**

As in previous context profiles, it is assumed that the Intellectual Capabilities and IT Concepts outlined in the FITness report are addressed by the college curriculum as a whole, though CMPU 101 is the primary vehicle through which most students increase their fluency with IT. Of those topics deemed most important for a liberal arts graduate, CMPU 101 contributes to the ability to engage in sustained reasoning through a series of more complex programming assignments, discusses the digital representation of information, stresses functional and data abstraction and, through the Walker text, presents the limitations of information technology as well as its societal impact. Other important components are covered more broadly throughout the curriculum, for example, the ability to organize and navigate information structures, to collaborate with others, and to communicate effectively. None of the IT Skills listed in the appendix are taught for credit, but are available to students via short workshops as mentioned below.

Science majors are expected to have higher levels of fluency in a number of key areas, which is provided both by further courses within Computer Science and other major-specific courses. Students taking CMPU 102 and CMPU 203, the next two courses in the introductory sequence, gain additional experience in managing complexity, testing solutions, diagnosing and correcting faults, and collaborating on larger projects. (CMPU 102 is a programming and data structures course taught in Java, and CMPU 203 is a software development course taught in C++. See [www.cs.vassar.edu](http://www.cs.vassar.edu) for additional course details.) The CMPU 102–203 sequence also provides additional exposure to algorithmic thinking, key aspects of computer organization, and the universality of computing machines. An upper-level elective can be taken to address networking concepts.

Other departments on campus offer discipline-specific computing courses that expand fluency. For example, the Physics department offers PHYS 270, "Computational Methods in the Sciences", and the Math department offers a course on the mathematics and algorithms involved in modern cryptography. Also, courses in Astronomy, Biology, Chemistry, Geology, and Physics take advantage of the Scientific Visualization Lab

(mentioned below) to do simulation, visualization, and real-time interactive demonstrations.

### IT Resources

The Computer Science Department maintains a lab of 14 Macintosh computers that are used exclusively by CMPU 101 for both closed lab sessions and programming assignments. It also manages a lab of 14 Sun workstations, and an eight-processor Sun Enterprise 3500, which are available to students in subsequent courses. The department has a full-time (academic year) system administrator who cares for the hardware, ensures system security, and manages software installations and upgrades. Outside of the Computer Science Department, students have access to several large general-purpose computing labs (primarily PC-based), smaller labs in each of the dormitories, and the Scientific Visualization Lab, consisting of six SGI workstations and a high-resolution projection system. All buildings on campus have Ethernet access, and the Computer Science department also offers wireless networking. Students have unlimited access to printing facilities across campus.

The office of Computing and Information Services offers a variety of short workshops on the use of common productivity applications and web page design tools. (These are not offered for credit.) Vassar has an interdisciplinary “Science, Technology, and Society” program as well, that offers courses on the history, ethics, and legal implications of technology.

### Scheduling

A total of five sections of CMPU 101 are offered each year, three each fall and two in the spring semester. As each section is limited to 20 students, the total yearly enrollment does not exceed 100. The course meets twice a week for 75 minutes, and includes a two-hour closed lab session each week. While not specifically required for any graduation requirement, the course is one way for students to satisfy a quantitative analysis requirement. In addition, three sections of CMPU 102 are offered each year, one in the fall and two each spring semester. Each section is limited to 20 students, so the total yearly enrollment does not exceed 60. The course meets twice a week for 75 minutes, and includes a two-hour closed lab session each week. CMPU 203 is offered at least once each semester, and also meets for two 75-minute lectures each week.

### Comments/Comparison to “FITness” Goals

*It works better if...*

- ❑ Faculty teaching CMPU 101 are aware of IT fluency issues, and understand the role of the course in promoting FITness. Otherwise, material seen as not directly supporting the Computer Science major has a tendency to be minimized or skipped.
- ❑ There is a clear sense of other sources of IT fluency on campus, and the course is tailored to complement them if possible.
- ❑ Students with an interest in science should start taking Computer Science courses as early as possible, otherwise they may not leave enough time in their schedules to take the three courses recommended for all science majors. Starting early also leaves students time to take additional CS courses if they choose.

*It doesn't work if...*

- ❑ Faculty advisors in other departments are unaware or unconvinced of the importance of FITness. Since none of the courses mentioned above are required, it is up to individual faculty members to ensure that their advisees receive adequate IT fluency. Unless they understand the goals of CMPU 101, they may be unlikely to recommend it to students majoring in the arts.
- ❑ Science faculty fail to recognize that IT fluency requires more than just programming ability. A common pitfall is to recommend a course like “Computational Methods in the Sciences” instead of the more comprehensive series of courses described above.

### CONCLUSIONS

The results of the working group can be stated in three general concluding statements.

- ❑ It is critical that faculty members from the computing department be involved in the development and implementation of these courses so that they do not devolve into literacy or skills courses. We will provide some thoughts on various directions this involvement might take in the section on “Engagement of the Computing Community” that follows.
- ❑ The content of each course will drive the design and delivery of that course. There is no single way to develop fluency with IT.
- ❑ The planning, development and implementation of IT fluency should be the responsibility of the entire institution. This approach is similar to literacy requirements that are centralized. This recommendation reinforces the recommendation on page 59 of [6].

We have developed an additional set of three recommendations for future research directions:

- ❑ A context-specific library of resource materials should be developed for use by institutions. A future working group can flesh out this proposal further. The website ([www.cs.haverford.edu/ITfluency](http://www.cs.haverford.edu/ITfluency)) can serve as a place to begin this process.
- ❑ Work must be done on how to “sell” this idea to both the academic and the outside client communities. Selling this idea to the academic community will involve selling the message that fluency is different than literacy to teaching academics, as well as selling university administrators and leaders on the importance of this concept.
- ❑ Work must be done on how to begin building IT fluency at the secondary school level. The NRC report [6] offers several comments on how this needs to be addressed. We believe that the message must get out to teachers colleges and education departments in universities, and to the public at large on the need to develop a FIT society.

### MODELS FOR THE ENGAGEMENT OF THE COMPUTING COMMUNITY

The roles and responsibilities of computing in promulgating, delivering, or advising on IT fluency initiatives may take many forms. Computing may best be thought of as a discipline partner with other stakeholder programs and disciplines undertaking IT fluency initiatives. The degree of ownership can be viewed as a continuum from full computing design and delivery through joint

models, to full discipline responsibility with minimal computing involvement. Here are some possible types of ownership models:

- Computing Department/Program Responsible
- Host Program Responsible
- Host Discipline Responsible
- Jointly Responsible (*i.e.*, Computing and Host)
- Institution Responsible

The authors of this report believe that developing IT fluency is most productively regarded as a process of partnership, wherein computing faculty act in roles ranging from curriculum advice, through certification of faculty intended to teach the course, to team-teaching and full delivery models. Whichever model is chosen in the context of use, it must be acknowledged that the curriculum and its delivery are negotiable, and the strength of the relationship between the computing department, those faculty chosen to teach the course, and the host program or discipline, will be critical determinants of success. The list below identifies some key educational functions, in an extension of those used by [3].

- technology
- administrative services
- promotion and marketing
- curriculum design
- content development
- curriculum review
- faculty supervision
- faculty recruitment
- faculty confirmation (Q/A)
- instruction
- assessment
- awarding credit
- overall quality control

We believe this area warrants considerable further research. From analysis of current successful efforts in IT fluency there may well emerge three or four primary configurations, which most appropriately deliver the best outcomes for all parties, involved in an IT fluency initiative. These might then be proposed as normative models for others to adopt.

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# APPENDIX

Category - Intellectual Capabilities			Institutions & Contexts						
	Rivier	AUT	AUT	RMC	RMC	Vassar	Haverford	CUE	CUE
Component	Nursing	Business	Business-IT	Business	Engineer	Arts CS1	Arts CS0	Informatics Economics	Other
Engage in sustained reasoning	High	Low	High	High	High	High	High	High	Low
Manage complexity	Low	Low	Medium	High	High	Medium	Low	High	Low
Test a solution	Medium	Low	Medium	High	High	Medium	Low	Medium	Low
Manage problems in faulty solutions	Low	Low	Medium	High	Medium	Low	Low	High	Low
Organize and navigate information structures and evaluate information	High	Low	High	Low	Low	High	High	High	Low
Collaborate	High	High	High	High	High	Medium	Medium	High	High
Communicate to other audiences	Low	High	High	High	High	Medium	Medium	High	High
Expect the unexpected	Medium	Low	Medium	High	Medium	Medium	Medium	High	Low
Anticipate changing technologies	Low	Low	High	High	High	Low	Low	High	Low
Think about Information Technology abstractly	Low	Low	High	Low	Medium	Medium	Medium	High	Low

<b>Category - Information Technology Concepts</b>	<b>Institutions &amp; Contexts</b>								
	<b>Rivier</b>	<b>AUT</b>	<b>AUT</b>	<b>RMC</b>	<b>RMC</b>	<b>Vassar</b>	<b>Haverford</b>	<b>CUE</b>	<b>CUE</b>
<b>Component</b>	<b>Nursing</b>	<b>Business</b>	<b>Business IT</b>	<b>Business</b>	<b>Engineer</b>	<b>Arts CS1</b>	<b>Arts CS0</b>	<b>Informatics Economics</b>	<b>Other</b>
Computers	High	Low	Medium	High	High	Low	Low	High	Low
Information Systems	High	Medium	High	High	Low	Low	Low	High	Medium
Networks	Low	Low	High	High	Medium	Low	Low	High	Low
Digital Representation of Information	Low	Low	Medium	High	High	High	High	Medium	Low
Information Organisation	Medium	Low	High	Medium	Medium	Low	Low	High	Low
Modeling and Abstraction	Medium	Low	Medium	High	High	High	High	Medium	Low
Algorithmic thinking and programming	High	N/A	Low	Low	High	Medium	Low	High	Low
Universality	N/A	N/A	N/A	High	High	Medium	Medium	Medium	N/A
Limitations of Information Technology	Low	Medium	High	High	High	High	High	Medium	Low
Societal impact of Information and Information Technology	High	Medium	Medium	High	Low	High	High	Medium	Medium

Category - Information Technology Skills		Institutions & Contexts							
	Rivier	AUT	AUT	RMC	RMC	Vassar	Haverford	CUE	CUE
Component	Nursing	Business	Business IT	Business	Engineer	Arts CS1	Arts CS0	Informatics Economics	Other
Setting up a PC	Low	N/A	Low	Medium	High	Medium	Medium	Medium	N/A
Using basic operating system features	High	Low	Low	Low	Medium	High	High	High	Low
Using a word processor ...	Low*	Medium	High	High	High	High	High	High	High
Using a graphics ... to create image-based expressions of ideas	High	Medium	Medium	High	High	Low	Low	High	Medium
Connecting a computer to a network	Low	N/A	Low	Low	Medium	Medium	Low	High	N/A
Using the Internet to find information and resources	High	Medium	High	High	High	High	High	High	Medium
Using a computer to communicate with others	Medium	Medium	High	High	High	Medium	Medium	High	Medium
Using a spreadsheet ...	High	Medium	High	High	High	Medium	Medium	Medium	High
Using a database system ...	High	Low	High	Medium	Low	Low	Low	High	High
Using instructional materials to learn how to use new applications or features	Medium	Low	Medium	Medium	Medium	Medium	Medium	Medium	Low

*\*completed outside of the class*